1946 Edison Medal Presentation

PRESENTATION of the 1946 Edison Medal to Lee de Forest (F '18) "for pioneering achievements in radio and for the invention of a grid-controlled vacuum tube with its profound technical and social consequences" was made by AIEE President J. Elmer Housley on Tuesday, January 27, at a general session of the 1947 AIEE winter meeting. David Sarnoff (M '23) introduced the medalist. The history of the medal itself was given in *ELECTRICAL ENGINEERING* for February 1947, page 122.

Lee de Forest

DAVID SARNOFF
MEMBER AIEE

DESTINY has an ingenious way of staging the drama of progress through science, for seldom are the actors gathered together and rehearsed. Each plays his part when time and opportunity give the cue. We find that new ideas are born at unexpected moments, in unusual places, and by unsuspected genius. Radio is a good example that reveals how science and fate join in extending the cavalcade of man's progress in art, science, and industry.

Let us recall a particular case—an act in the drama of radio science that is especially appropriate on this occasion. In America, a farm boy named Thomas Alva Edison was born 100 years ago, destined to discover an electric lamp to light the world. On the other side of the Atlantic, in England, another boy—John Ambrose Fleming—was born two years later, and as a young man his fascination with electricity and wireless led him to study the Edison lamp.

Something whispered to Fleming that it might possess unique possibilities as a detector of wireless waves. He had read of the mysterious effect of electrons at play within the glass bulb of Edison's lamp. He wondered if those electrons might be harnessed to make the lamp act as a valve to control the flow of a radio circuit, in much the same way as a valve serves in a water pipe. He ardently pursued the idea, and as a result he invented the Fleming valve which we call a "tube." It was the first electronic detector of wireless signals.

BIRTH OF DE FOREST

The scene shifts back to America. At Council Bluffs, Iowa, on August 26, 1873—26 years after the birth of Edison—a boy was born and named Lee de Forest. He was "cut out in his father's hopes" to be a minister. But he turned instead to science. He went to Yale University, as his father had done. But at New Haven the pathways of their careers diverged sharply. Young de Forest heard Professor Henry Bumstead lecture on electromagnetic waves and watched him demonstrate the Hertz experiments. From that day on, Lee de Forest had wireless in his blood, and, I surmise, some electrons too!

Naturally, he read everything he could find on the subject, and everything he read fired his fertile imagination. He was enthralled by the achievements of Marconi. He learned how Fleming had invented the valve detector, but this device would not amplify the current it controlled. What the valve detector needed, so it seemed to de Forest, was a device to control the local currents that were induced by the incoming wireless waves. So in 1906, 40 years ago, de Forest added a third element to the valve by inserting a zigzag piece of platinum wire between the filament and plate. He called it a "trigger," or "grid," and named the new 3-element tube the Audion. It is a generator of Hertzian waves, as well as a detector and amplifier of these ethereal, wireless messengers. The electron tube now is recognized as one of the 20 great inventions of all time.

At the birth of the Audion, de Forest predicted its future in these words: "Little imagination is required to depict new developments in radiotelephone communications, all of which have lain fallow heretofore, waiting for a simple lamp by which one can speak instead of read."

But the electron tube far has surpassed that early-day prediction. Radio learned to talk and to sing. And the invention of the young man who did not follow his father into the pulpit has made, perhaps, an even greater contribution in spreading the gospel to the far corners of the earth.

USES OF ELECTRON TUBES

Because of their versatility, we find millions of electron tubes at work throughout the world. They are used in electrical communications and signaling, with or without wires. Modern telegraphy, telephony, radio, motion pictures, phonographs, transportation, navigation, aviation, and hundreds of industrial operations now employ de Forest's basic invention. It is a significant fact that this invention has withstood the test of time over a period of 40 years and that it still continues to enlarge its field of usefulness.

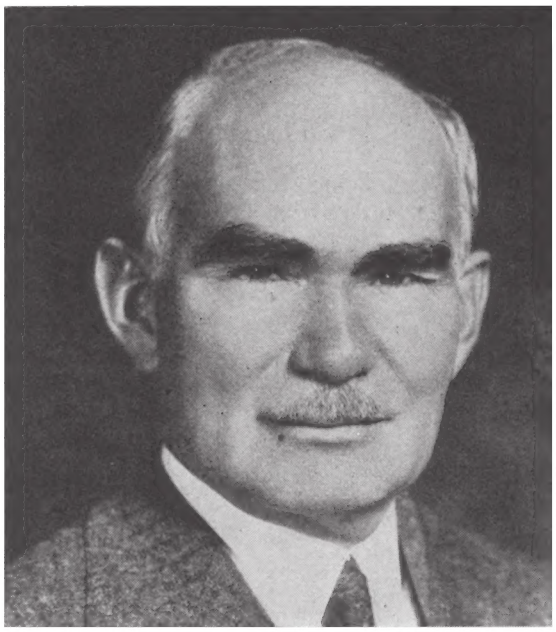
Electron tubes also were a key to victory in the war. Without them, many devices that helped to defeat the enemy might not have been available. Today these

Full texts of the speech of introduction made by General Sarnoff and the speech of acceptance by Doctor de Forest.

David Sarnoff is president of the Radio Corporation of America, New York, N. Y.

tubes are one of the hopes for the attainment of peace through freedom to listen, and thereby to achievement of a better understanding between the peoples on this earth. Statesman or peasant has but to snap a little switch, and the electron tube pulses with the pulse of the entire world.

There would not be time enough in all this afternoon to evaluate the universal triumphs of the modern electron tube. Our purpose today is to honor the man who, through his invention of the Audion, made an important contribution to science and society. It has been my privilege to have known him for many years, and it is indeed a pleasure to see him here today. He has crossed the threshold of three score and ten, but he still has the same faith in the future and the same spirit of pioneering that always have characterized him.



I am honored to present on behalf of the American Institute of Electrical Engineers, the 1946 Edison Medalist, Doctor Lee de Forest, who will receive this high award "for pioneering achievement in radio and for the invention of the grid-controlled vacuum tube with its profound technical and social consequences."

The Audion

LEE de FOREST
FELLOW AIEE

IN MY YOUTH I learned a Bible verse which read, "If ye have faith, all these things shall be added unto thee," which in my case I found should be supplemented thus—"faith, plus longevity!" The laurel is better late than posthumous!

I am happy, indeed, today to be so fortunate as to have lived to realize one prize to which I had long aspired, the great honor which your committee has bestowed upon me, the Edison Medal.

From early boyhood, Thomas A. Edison was my ideal, my living inspiration, my idol. My ever-present ambition was to be able to achieve something, sometime, which might be compared with his incandescent lamp or his phonograph, a thing revolutionary in nature, applicable to the needs of a continually unfolding, ever-developing society.

Commencing almost with the beginning of the wireless telegraph, I sought to apply to that new enterprise my newly acquired knowledge of Hertzian waves, their generation, and reception. Because I had to build my own equipment, I, perforce, concentrated on a new wireless detector, for it was cheap to construct, and for experiment.

EVOLUTION OF THE AUDION TUBE

Almost at the start, a lucky observation of a gas burner which fluttered in accordance with signals from my small spark gap led my thinking into a channel as different as possible from that of the responder on which I was then at work. Although the observed action proved to be wholly acoustic and not electromagnetic, I became firmly convinced that the Hertzian waves, or their derived currents, could be made to affect the conductivity of gases, with electrodes heated to incandescence therein. Three years later I proved that my idea was well founded when wireless telegraph signals were received with a Bunsen burner detector having in its flame two platinum electrodes, one of them incandescent. A slow evolution from this stage brought me, in 1906, to the so-called Audion, described in a paper presented that summer before a New York session of the Institute (The Audion. AIEE *TRANSACTIONS*, volume 25, 1906, pages 735–63.)

In the "flame responder," the hotter electrode was connected to the negative terminal of a 6-volt dry battery and to earth. The positive battery terminal led to a telephone receiver, from the other terminal of which a wire led to the second electrode located in the flame. To this terminal also was connected the receiving antenna. Through all this work I, naturally enough, was seeking to create a genuine relay—a trigger device, whereby the weak incoming signal could control the flow of a local battery current of relatively vastly greater power.

Consequently, when I later heated my cathode and enveloping gas electrically, as by employing a small carbon filament sealed in a partially evacuated glass vessel—a great step in refinement from the open flame—I still employed that other essential element of my first devices, the anode, or *B*, battery.

In the summer of 1906, the Audion (as my assistant, Babcock, cleverly named it) embodied, in a glass

Lee de Forest is founder and president of the Lee de Forest Laboratories, Inc., Los Angeles, Calif., and also at present is associated with the American Television Laboratories, Chicago, Ill.

envelope, the elements of the flame detector, heated cathode, relatively cold anode, local battery, and signal indicator. The control electrode was added next, first in the simple form of a strip of tin foil wrapped around the tube. This was primarily to increase the sensitivity of the device by preventing any shunting of the received energy through the anode-to-earth path. Prior to that, the antenna lead, or its equivalent, had been connected directly to the anode.

CONTROL ELECTRODE

This crude control electrode proved a definite improvement. Successive steps in increasing sensitivity of this new detector: placing the control electrode in the form of a plate, like the anode, within the envelope, but on the opposite side of the filament cathode; next locating this electrode between the cathode and anode in form of a perforated plate; and finally, for simplicity of construction, the addition of a short piece of platinum or nickel wire bent in the form of a grid. This last step was late in 1906.

During that year my various models were constructed and pumped by William McCandless, maker of miniature lamps, whose kindly sympathy was a definite essential to my groping progress. His were mechanical pumps only, so that my anode voltages during this epoch were necessarily low—of the order of 15 to 22 volts. Through all this work, the writings of J. J. Thompson were my Bible—and constantly were consulted.

The Audion, until 1912, remained only a detector of wireless signals, happily by far the most sensitive detector existent, as proved by the ever-increasing eagerness of the then "hams" to acquire one of these coveted bulbs, by hook, crook—or purchase, if need be—at a fabulous cost of $8, with filament life unguaranteed, but hopefully of the order of 30 hours!

From time to time the statement has appeared that in my invention I contributed the grid to a rectifier tube, or valve, and thereby created the Audion or the 3-electrode tube, the present heart and soul of radio communication. What could be more simple in the way of an explanation? What at the same time further from the truth, and still further from a knowledge of the simple facts of electronic principles?

To recognize that the anode voltage is as essential a feature of the Audion as is the third electrode, that by virtue of this local energy alone is the Audion a relay device, and therefore an amplifier of transcendent value, instead of a mere rectifier of received alternating currents —seems to be so self-apparent, that I always have been at a loss to understand why anyone should fail to grasp it. Yet such is the very common position of many writers: "The Audion is the Fleming valve with a third electrode." "Its inventor improved the valve merely by the addition of the grid."

Add a third, or any number of electrodes to the simple diode, and it remains a valve—a mere rectifier, possessing the utility of the rectifier, and nothing more.

The evolution of the Audion patent claims marks, in a general but incontestable manner, the evolution of the Audion; first it was a gas effect in the open air, then in an enclosed vessel, then in an exhausted vessel, exhausted like an incandescent lamp, then to higher and higher degrees of vacuua (as early as 1912 I employed an "X-ray" vacuum). But always it was a relay. Always the *B* battery was employed. The control electrode idea preceded even the enclosed vessel. And never at any time was the Audion "the Fleming valve with merely a grid added."

It was by the devious path just outlined, that I finally arrived at the grid-controlled amplifier.

APPLICATION IN TELEPHONE FIELD

In October 1912, having developed the Audion amplifier as far as was feasible with the resources at my command, I asked my good friend John Stone to bring to the attention of the Western Electric engineers the possibility of using this amplifier in their long-distance lines, and particularly in the transcontinental service which they were asked to install between New York and San Francisco against the opening of the Panama–Pacific Exposition. At the invitation of Doctor Frank Jewett I proceeded to demonstrate to his engineers the 3-stage Audion amplifier. The potentialities of this new device for telephone needs was appreciated immediately by the Telephone Company, and the task of further developing the tube for long-lines communication was given to Doctor H. D. Arnold. So skillfully did Doctor Arnold and his staff undertake the further refinement of the amplifier tube, that within two years transcontinental telephone service was established. The zeal and rare understanding of the elements of the problem, with which that staff of trained men developed the amplifier and applied it to the long-sought transcontinental telephone line, stand unique in the annals of brilliant achievement in electrical engineering. Too much credit cannot be given to the engineers and scientists of the Bell System for the splendid manner in which the tube, both as amplifier and as oscillator, generator of alternating currents of almost any frequency, has been developed and refined, since its initial presentation to them. Within three years thereafter the human voice had spanned the Atlantic!

Following the close of the first World War, I resumed my early broadcasting work, using the oscillator tube at the transmitter and the Audion detector and amplifier at the receiver. With these three necessary components so well developed at that time, the possibilities of the radiobroadcast began to be appreciated by various commercial agencies, and with such zest that during the 1920's a new major industry attained maturity, demonstrating its unlimited possibilities, commercially and culturally, fittingly to be described as an "expanding

universe," an instrumentality which has been compared justly with the invention of printing.

The magnitude of the magic of this thing of broadcasting came overwhelmingly upon me one day when, motoring through the California mountains, I listened to grand opera being sung at that instant in Moscow, Russia. Today any one of us can be witness to a similar miracle, due primarily to the ability of a chain of small evacuated tubes to amplify by a billion times, the inconceivably minute energy received from small transmitting stations, located, if you please, at the antipodes.

The electron emerged from the university laboratory briefly before the beginning of the century. Its application to the service of man dates from the first knowledge of how to control its migrations through *vacuo*. Starting with that discovery, the utility of this new physical tool has accelerated so amazingly that the first half of our century is fittingly termed, "The Electronic Age."

From such humble tasks as control of a drinking fountain, to transmitting a signal to our moon and return, even to those involved in the process of the cyclotron, where the foundation stones of our universe are shattered, scarcely a phase of activity in science, technology, or medicine has failed to demand essential aid from the vacuum electron.

Lee de Forest and AIEE President Housley at the presentation ceremonies

USE IN OTHER FIELDS

In fields other than the telephone, early outstanding work in research and invention was undertaken by engineers of the Radio Corporation of America, notably in that of radio communication, and in the production of receiver–amplifier tubes of multitudinous forms and in astronomical quantities; by the General Electric Company in giant power tube design; by the Westinghouse Company in its application to a hundred industrial uses.

Outstanding names among many early leaders in electron investigation since 1912 are Pierce, Chaffee, and Zworykin, that genius who wedded the Iconoscope to the grid amplifier to give television to the world.

Following the first World War, every large electrical corporation in Europe began intensive development of the tube for every possible application; and World War II incited to keenest research hundreds of competent laboratories, the combined knowledge and skill of which in four years advanced the electronic age further than 20 years of development in peace could have.

Following world communication and broadcasting, the tube with its manifold circuits has produced the talking picture; the living reproduction of recorded music; and television—gigantic new industries, now, or soon to be.

In addition to its colossal aid in winning the war, as by radar and the proximity fuse, the freed electron in peace has afforded new employment to millions, and has enriched the lives of hundreds of millions, hitherto dull and straitly confined.

Here in glass and metal lies the control of the world's greatest force, the electron. Here is man's eye to see through solids, beyond horizons, and to behold the infinitesimal, to make audible the inaudible, his voice heard around the world, his mastery of time, temperature, and motion.

ROLE IN SAFETY

In the electron tube lies the safety of all who fly, making possible today's crowded aviation; the tube which now stands mutely asking leave to end collision, by water, air, and rail; there being lacking only sufficient of man's humanity to man to put it, generally and intensively, to that merciful job.

Time is not afforded to catalog even a small fraction of the useful applications of this tube in every imaginable field of man's activity, commercial or spiritual, which during the past 25 years have been achieved; nor is my imagination equal to the prophecy of what new wonders will this Aladdin's lamp illumine for the world, during the remainder of our century. I count myself most fortunate among men to have been granted to live to see this gigantic unfolding of an implement, and an idea, which first came to me more than 40 years ago.